Facts from the Savannah River Site
ENVIRONMENTAL STEWARDSHIP • NATIONAL SECURITY • SCIENCE AND ENERGY

Robotic Technology

The U.S. Department of Energy's Savannah River Site (SRS) has 51 underground carbon-steel waste storage tanks, located in its two tank farms. These tanks were built to hold radioactive liquid waste from Cold War-era nuclear weapons production, and range in size from 750,000 to 1,300,000 gallons. Today, approximately 35 million gallons of radioactive liquid waste remains in 43 waste operational tanks. Eight of the tanks have been operationally closed.

Savannah River Remediation (SRR) uses robots in large waste tanks and in the liquid waste facilities to:

- Inspect the integrity of the waste tanks' systems;
- Remove waste from the tanks;
- Clean up contaminated tank surfaces and equipment;
- Retrieve samples of residual waste that cannot be removed from the tanks;
- Remove contaminated waste from liquid waste facility floors; and,
- Inspect and repair contaminated equipment inside the liquid waste facilities.

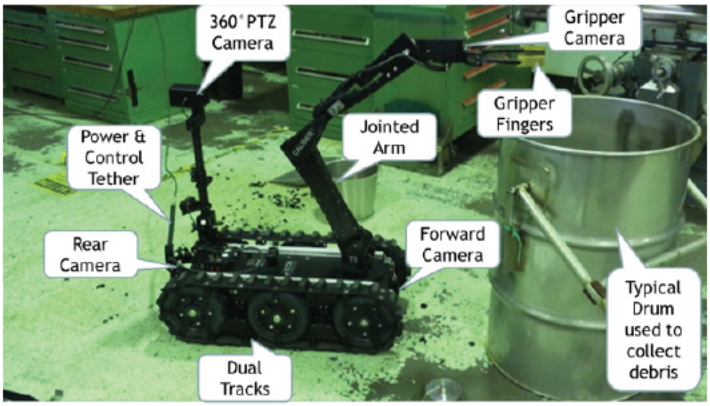
There are no plans to build additional waste tanks, so it is essential to validate the integrity of existing tanks and transfer systems. Service life management of these tanks includes an ongoing surveillance program where the primary and secondary tank walls in the annulus space and annulus pan floor are inspected with a remotely manipulated camera. Select areas receive additional higher resolution photography and ultrasonic inspections. The cameras and sensors for these inspections are deployed on 'wall crawler' robots.

Both chemical and mechanical techniques are used to remove radioactive liquid waste from the tanks to the lowest levels practical. These removal techniques have been further improved using robots inside of the waste tanks. Several different robots have been used to achieve further removal of waste material as well as retrieval of samples of the waste for laboratory evaluation.

Waste removal in SRS waste tanks is completed in a series of steps. The first step removes the bulk, or most significant volume of radioactive liquid waste, and leaves behind a much smaller waste heel. Mechanical and chemical techniques are used in the second waste removal step to take out more of the hard-to-reach waste, leaving behind an even smaller amount of residual waste material. Additional steps, depending on the physical characteristics of each tank, may include cooling coil flushing or annulus cleaning.

After the applicable radioactive liquid waste removal steps are completed, samples of the residual waste material must be retrieved and submitted for laboratory evaluation. Those results are analyzed to ensure the tank is ready to be operationally closed and filled with a cement-like grout.

Remotely controlled robots equipped with tools and cameras are inserted into waste tanks to obtain laboratory samples of residual waste.



The ICOR Technologies Caliber T5 is a two-track crawler with a jointed robotic arm and cameras.

The PAC 3 robot has been used to help clean cells inside the Defense Waste Processing Facility.

U.S. DEPARTMENT OF ENERGY

The Savannah River Site is owned by the U.S. Department of Energy. Savannah River Nuclear Solutions is the management and operations contractor at the Savannah River Site. Savannah River Remediation is the current liquid waste contractor at the Savannah River Site.

SRS SAVANNAH RIVER SITE

December 2020

The Robots

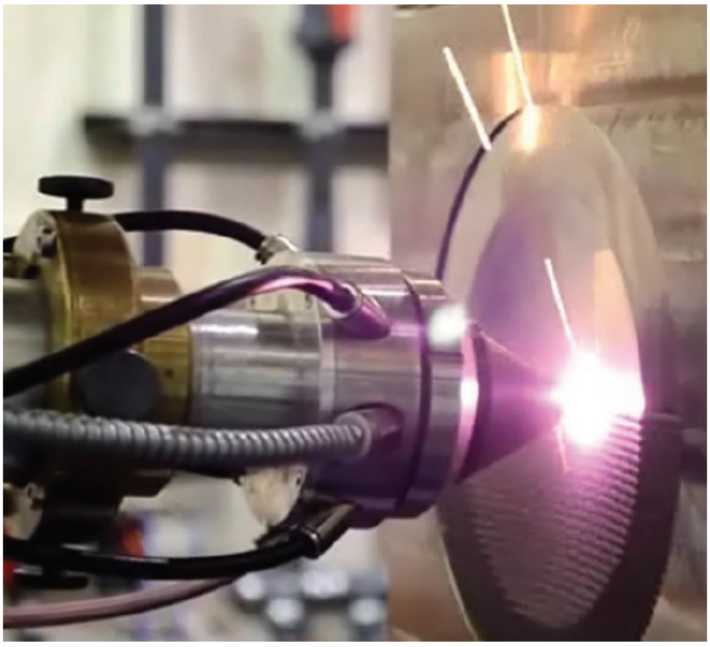
The Small Roving Annulus Inspection Vehicle (SRAIV) is a modified, commercially available wall crawler designed to implement the In-Service Inspection (ISI) of waste tanks, along with digital video and still definition photography. The SRAIV provides an improved capability to achieve a more complete inspection of waste tank walls than previous methods. The SRAIV is deployed through annulus risers in a waste tank to gain access to tank walls requiring inspection. The SRAIV is deployed using a manually operated deployment pole and is coupled to the wall using permanent magnet wheels. Navigation is performed from the remote console where pictorial views can be displayed from the on-board cameras. The unit incorporates multiple ultrasonic inspection (UT) transducers for traditional weld examination. These surveillances are performed on surfaces in the annulus in a systematic manner. Remotely controlled magnetic wall crawlers equipped with cameras and ultrasonic transducers integrated with commercially available "P-scan" data analysis equipment have been used to ultrasonically inspect tank walls, weld areas, and leak sites.

The Sand Mantis, which was built specifically for work at SRS, has been used for removing residual radioactive liquid waste from waste tanks that have cooling coils using a water-jet system that transfers the material to a grinder for grinding into smaller particles that can be more easily removed. It sprays highly pressurized water from a tiny opening made of specially selected material that can stand up to the water's pressure over time. The complete robot is 8 feet long and weighs approximately 800 pounds. The Sand Mantis' cross-shaped body can be collapsed into a straight line for insertion through the small openings in the top of a tank. Once inside, the robot unfolds and is remotely guided.

Frankie, a commercially available robot, was modified by liquid waste contractor SRR, moves across waste tank floors on treads. Frankie's primary function is to scoop thin layers of residual material left behind from heel removal and cleaning processes. Posing less risk to workers, Frankie replaces a custom-built vial that was scraped along the tank floor.

Innovations have led to the creation of G.I. Joe, a sampling robot. An enhancement of Frankie, G.I. Joe was also a commercially available design that was modified by SRR in order to obtain better samples of residual waste, while reducing exposure to workers. The arm grips a scoop that is dragged along the tank floor. Once the scoop is filled with material, an engineer uses cameras and remote controls to maneuver the robot to another area within the tank where the scoop is placed into a basket. The basket is then lifted out of the tank, and the sample is sent to the laboratory for analysis.

A specialized robot was deployed at the Defense Waste Processing Facility (DWPF) to support remote cell cleaning operations. After more than a decade of continuous melter operations, a significant quantity of glass shards and refuse maintenance equipment had accumulated on the floor of the Melt Cell. The facility needed to clean the debris to minimize risk to equipment within the cell. The ICOR Technologies Caliber T5, a two-track crawler with a jointed robotic arm and cameras was deployed in the cell. The task was to collect bulk debris in 55-gallon drums and remove glass from the floor. The robot can use tools, such as a push broom and dustpan, to move and collect bulk volumes of glass. A similar crawler was used to inspect the sand filter at DWPF.



Robots repaired the 3H Evaporator with an affixed cap over the cone area by using a precision powder injection laser.

The KUKA robotic arm attached to the BROKK 100 robotic base work as one robot for performing remote repair work in the liquid waste facilities.

U.S. DEPARTMENT OF ENERGY

The Savannah River Site is owned by the U.S. Department of Energy. Savannah River Nuclear Solutions is the management and operations contractor at the Savannah River Site. Savannah River Remediation is the current liquid waste contractor at the Savannah River Site.

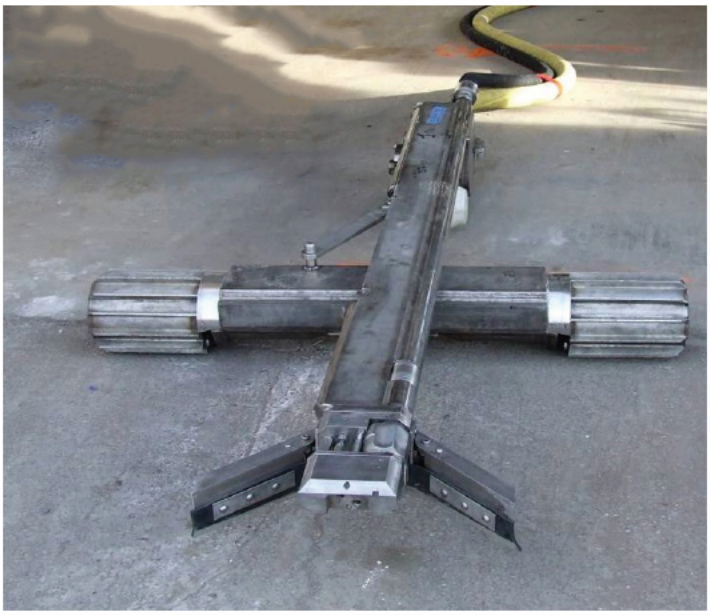
SRS™ SAVANNAH RIVER SITE

PackBot is a remote-controlled robot whose primary functions is to perform inspection work. This was commercially procured from a vendor and modified by SRR. PackBot performs remote inspection work at DWPF.

The KUKA robotic arm attached to the BROKK 100 robotic base is a specialized combination of two commercially available robotic devices that were modified by SRR to work as one robot for performing remote repair work in the liquid waste facilities. The robots were used to detect leak sites and perform repair work in the 3H Evaporator vessel.

The KUKA robotic arm attached to the BROKK act as one body. It can fit through doorways and travel around tight spaces. The BROKK can hold multiple attachments, such as a hammer, shear, claw, bucket, and other manipulators. For SRR, it is used to hold the KUKA arm to perform remote work. The KUKA robotic arm can pick objects up and move them around quickly, when programmed. The KUKA robotic arm is used worldwide in industries from automotive to healthcare.

For the 3H Evaporator repair, the BROKK moved around the floor of the evaporator cell and KUKA arm was used in several ways. First, the arm maneuvered specialized cutting tools to remove the lagging and the insulation around the vessel. Next, the KUKA arm deployed a camera inside the evaporator cell to perform inspections of the general leak site, and then held an ultrasonic probe that measured the thickness of the evaporator vessel walls surrounding the leak sites. The combined robots repaired the 3H Evaporator with an affixed cap over the cone area by welding 186 weld beads 360 degrees around the cap using a precision powder injection laser.



The Sand Mantis has been used for removing residual waste from tanks.

The Small Roving Annulus Inspection Vehicle is a modified, commercially available wall crawler designed to implement the In-Service Inspection of waste tanks.

U.S. DEPARTMENT OF ENERGY

The Savannah River Site is owned by the U.S. Department of Energy. Savannah River Nuclear Solutions is the management and operations contractor at the Savannah River Site. Savannah River Remediation is the current liquid waste contractor at the Savannah River Site.

SRS™ SAVANNAH RIVER SITE

December 2020